

Form PTO-1390  
(REV 10-95)

U.S. Department of Commerce Patent and Trademark Office

ATTORNEY'S DOCKET NUMBER

FMW-RR-PCT-US

**TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371**

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

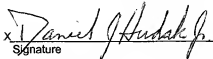
**10/018198**INTERNATIONAL APPLICATION NO.  
PCT/EP00/05366INTERNATIONAL FILING DATE  
10 June 2000PRIORITY DATE CLAIMED  
16 June 1999TITLE OF INVENTION: **MICROMIXER**APPLICANT(S) FOR DO/EO/US: **EHRFELD, Wolfgang; MICHEL, Frank; LOHF, Astrid; GRAEFF, Volker**

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Article 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19<sup>th</sup> month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☒ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2))
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ has been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3))
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**Items 11. to 16. below concern document(s) or information included:**

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.  
A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☐ Other items or information:

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)		INTERNATIONAL APPLICATION NO. PCT/EP00/05366		ATTORNEY'S DOCKET NUMBER FMW-RR-PCT-US	
10/018198					
17. <input checked="" type="checkbox"/> The following fees are submitted:				CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492(A)(1)-(5))					
Search Report has been prepared by the EPO or JPO ..... \$890.00					
International preliminary examination fee paid to USPTO (37 CFR 1.482) ..... \$710.00					
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) ..... \$740.00					
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... \$1,040.00					
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) ..... \$100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				\$890.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492(e))				20 <input type="checkbox"/> 30 <input type="checkbox"/> \$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	17-20=	0	X\$18.00	\$0	
Independent Claims	1-3=	0	X\$80.00	\$0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+\$270.00	\$0	
TOTAL OF ABOVE CALCULATION =				\$890.00	
Reduction of 1/3 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28)				\$0	
SUBTOTAL =				\$890.00	
Processing fee of \$130.00 for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492(f)).				20 <input type="checkbox"/> 30 <input type="checkbox"/> \$0	
TOTAL NATIONAL FEE =				\$890.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property				\$0.00	
TOTAL FEES ENCLOSED =				\$890.00	
				Amount to be refunded: \$	
				Charged: \$	
<p>a. <input checked="" type="checkbox"/> A check in the amount of <b>\$890.00</b> to cover the above fees is enclosed.</p> <p>b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.</p> <p>c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit No. 08-3150. A duplicate copy of this sheet is enclosed.</p>					
<p>NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.</p>					
<p>SEND ALL CORRESPONDENCE TO:</p> <p>Daniel J. Hudak, Jr. Hudak &amp; Shunk Co., L.P.A. 7 West Bowers Street, Suite 808 Akron, Ohio 44308-1133 (330) 535-2220</p>					
<p>x  Signature</p> <p>Daniel J. Hudak Jr. _____ Name</p> <p>47,669 _____ Registration Number</p>					

**PATENT COOPERATION TREATY  
U.S. RECEIVING OFFICE  
TO THE INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY**

**Applicant:** Wolfgang Ehrfeld  
**International Application No.:** PCT/EP00/05366  
**International Filing Date:** 10 June 2000  
**Title:** MICROMIXER  
**Agent's Reference No.:** FMW-RR-PCT-US  
**Date:** December 14, 2001

**PRELIMINARY AMENDMENT**

Sir:

Please amend the application as indicated below before calculation of the application fees as follows:

**IN THE SPECIFICATION:**

Please amend the application as indicated below.

**Page 1:**

Please replace the first paragraph as follows:

**FIELD OF THE INVENTION**

The invention relates to a micromixer for mixing at least two reactants having penetrations for the supply of the reactants and discharge of the product, having at least one mixing plate with microstructures that define mixer cells, each of said mixer cells having a feeding chamber which adjoins at least one group of digital channels which intermesh in a comb-like manner with the digital channels of a group from the adjoining feeding

chamber; and having a discharge plate arranged on the mixing plate, said discharge plate having an outlet port above each mixing zone, said outlet port extending perpendicularly to the digital channels.

Page 1:

Please replace the second full paragraph as follows:

**BACKGROUND OF THE INVENTION**

Although microfluid components were developed years ago for analytical applications, microengineering techniques have only recently been applied to the development of equipment for chemical synthesis, so-called microreactors. Principle components of such microreactors are mixers and heat exchangers. Conventional static micromixers work according to the principle of multilamination to ensure rapid mixing by diffusion. This is the only mixing mechanism that can be used with laminar flows in microchannels. The creation of alternating laminations by means of geometric parameters allows good mixing in the microscopic range.

Page 2:

Please replace the third full paragraph as follows:

**SUMMARY OF THE INVENTION**

The object of the current invention is to provide a micromixer utilizing the same mixing principle as conventional micromixers but permitting significantly greater throughput at the same pressure drop.

Page 7:

Please replace the second full paragraph as follows:

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1a        a first embodiment of a mixing plate

Page 8:

Please replace the first full paragraph as follows:

#### **DETAILED DESCRIPTION OF THE INVENTION**

Fig. 1a shows a first embodiment of a mixing plate 20. This mixing plate 20 has two feeding chambers 33a and 33b for the reactants A,B. Both feeding chambers 33a,b branch into four primary channels 35a,b. Microstructures 31 defining the mixing zones 32 between the main channels 35 for the reactants A and B are located on both sides along the main channels 35a,b. The main channels 35a,b intermesh in a comb-like manner. The feeding chambers 33a,b together with the mixing zones 32 each form a mixer cell 30a and 30b.

#### **IN THE CLAIMS:**

Please substitute the following claims for the pending claim of the same number.

1. (Amended) A micromixer for mixing at least two reactants having penetrations for the supply of the reactants and/or the discharge of the product comprising: at least one mixing plate with

microstructures that define mixer cells, each of said mixer cells having a feeding chamber which adjoins at least one group of digital channels which intermesh in a comb-like manner with the digital channels of a group from the adjoining feeding chambers to form a mixing zone; and a discharge plate arranged on the mixing plate, said discharge plate having an outlet port above each mixing zone, said outlet port extending perpendicularly to the digital channels, wherein each mixer cell has at least two mixing zones.

2. (Amended) A micromixer as claimed in Claim 1, wherein the majority of the feeding chambers have parallel main channels that intermesh in a comb-like manner, with digital channels branching off of said main channels.
3. (Amended) A micromixer as claimed in Claim 1, wherein the majority of the feeding chambers are surrounded on all sides in the plane of the plate by mixing zones.
4. (Amended) A micromixer as claimed in Claim 1, wherein the feeding chambers are arranged according to the reactants in rows and/or columns in an alternating pattern.
5. (Amended) A micromixer as claimed in Claim 3, wherein the feeding chambers have a rectangular outline.
6. (Amended) A micromixer as claimed in Claim 3, wherein the feeding chambers have a triangular outline.
7. (Amended) A micromixer as claimed in Claim 3, wherein that side of the mixing plate facing away from the mixer cells is structured and has two storage chambers for the reactants;

has parallel channels which lead away from the storage chambers and run beneath the feeding chambers, whereby the channels for one reactant intermesh in a comb-like manner with the channels for the other reactant;

and has penetrations leading from the channels to the feeding chambers.

8. (Amended) A micromixer as claimed in Claim 3, wherein a first plate and below that a second plate are arranged below the mixing plate to form a storage chamber for the two reactants, and said storage chambers are connected via supply lines for the respective reactant to the corresponding feeding chambers, whereby the supply lines for the reactant in the lower storage chamber are hollow bodies which carry the reactant through the upper storage chamber.
9. (Amended) A micromixer as claimed in Claim 3, wherein the micromixer includes an integrated heat exchanger.
10. (Amended) A micromixer as claimed in Claim 9, wherein hollow bodies containing a heating medium or coolant are arranged on the discharge plate between the ports.
11. (Amended) A micromixer as claimed in Claim 9, wherein a heating medium or coolant is passed through the discharge plate.
12. (Amended) A micromixer as claimed in Claim 8, wherein a third chamber for a heating medium or coolant is arranged between the mixing plate and the two storage chambers for reactants, and both reactants are passed in hollow bodies through the third chamber en route to the feeding chambers of the mixing plate.

13. (Amended) A micromixer array for mixing one or more reactants comprising two or more stacked micromixers as claimed in Claim 1.
14. (Amended) A micromixer array as claimed in Claim 13, wherein the micromixers are fluidically connected in parallel.
15. (Amended) A micromixer array as claimed in Claim 13, wherein the micromixers are fluidically connected in serial.
16. (Amended) A micromixer array as claimed in Claim 15, wherein the micromixers for mixing three or more reactants are connected in serial, whereby the first micromixer is designed for mixing two reactants to produce a product, and at least one downstream micromixer is designed to mix the third reactant with the intermediate product.
17. (Amended) A micromixer array as claimed in Claim 13, wherein there are one or more additional plates above, below and/or between adjoining micromixers to supply reactant, collect and/or distribute intermediate products and/or to discharge the product.

**IN THE ABSTRACT:**

Please replace the original Abstract with the following Abstract:

**ABSTRACT**

Known static micromixers that work according to the principle of multilamination allow for a rapid mixing by diffusion. The invention provides a



means for substantially increasing the throughput of known micromixers. To this end, the inventive micromixer for mixing two or more reactants comprises microstructures that define mixer cells. Each of said mixer cells is provided with a feeding chamber which adjoins at least two groups of digital channels. Said channels intermesh with the digital channels of the groups adjoining the feeding channels in a comb-like manner, thereby producing mixing zones]. Outlet ports are located above said mixing zones, said outlet ports extending perpendicularly to the digital channels and discharging the product. The inventive micromixer is especially useful for the large-scale production of mixtures, dispersions and emulsions.

The following is a MARKED version of the amended pending claims, specification, and Abstract with all changes shown in conventional comparison.

**IN THE SPECIFICATION:**

Please amend the application as indicated below.

Page 1:

Please replace the first paragraph as follows:

**FIELD OF THE INVENTION**

The invention relates to a micromixer for mixing at least two reactants having penetrations for the supply of the reactants and discharge of the product, having at least one mixing plate with microstructures that define mixer cells, each of said mixer cells having a feeding chamber which adjoins at least one group of digital channels which intermesh in a comb-like manner with the digital channels of a group from the adjoining feeding chamber; and having a discharge plate arranged on the mixing plate, said discharge plate having an outlet port above each mixing zone, said outlet port extending perpendicularly to the digital channels.

Page 1:

Please replace the second full paragraph as follows:

**BACKGROUND OF THE INVENTION**

Although microfluid components were developed years ago for analytical applications, microengineering techniques have only recently been applied to the development of equipment for chemical synthesis, so-called microreactors. Principle components of such microreactors are mixers and

heat exchangers. Conventional static micromixers work according to the principle of multilamination to ensure rapid mixing by diffusion. This is the only mixing mechanism that can be used with laminar flows in microchannels. The creation of alternating laminations by means of geometric parameters allows good mixing in the microscopic range.

Page 2:

Please replace the third full paragraph as follows:

#### **SUMMARY OF THE INVENTION**

The object of the current invention is to provide a micromixer utilizing the same mixing principle as conventional micromixers but permitting significantly greater throughput at the same pressure drop.

Page 7:

Please replace the second full paragraph as follows:

[The current invention is described in greater detail below with reference to the attached drawings:]

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1a        a first embodiment of a mixing plate

Page 8:

Please replace the first full paragraph as follows:

#### **DETAILED DESCRIPTION OF THE INVENTION**

Fig. 1a shows a first embodiment of a mixing plate 20. This mixing plate 20 has two feeding chambers 33a and 33b for the reactants A,B. Both feeding chambers 33a,b branch into four primary channels 35a,b. Microstructures 31 defining the mixing zones 32 between the main channels 35 for the

reactants A and B are located on both sides along the main channels 35a,b. The main channels 35a,b intermesh in a comb-like manner. The feeding chambers 33a,b together with the mixing zones 32 each form a mixer cell 30a and 30b.

**IN THE CLAIMS:**

Please substitute the following claims for the pending claim of the same number.

1. (Amended) A micromixer [(10)] for mixing at least two reactants having penetrations [(12)] for the supply of the reactants and/or the discharge of the product[; having] comprising: at least one mixing plate [(20)] with microstructures [(31)] that define mixer cells [(30)], each of said mixer cells [(30)] having a feeding chamber [(33)] which adjoins at least one group of digital channels [(34)] which intermesh in a comb-like manner with the digital channels [(34)] of a group from the adjoining feeding chambers [(33)] to form a mixing zone [(32)]; and [having] a discharge plate [(21)] arranged on the mixing plate [(20)], said discharge plate [(21)] having an outlet port [(37)] above each mixing zone [(32)], said outlet port [(37)] extending perpendicularly to the digital channels [(34)], **[characterized by the fact that] wherein** each mixer cell [(30)] has at least two mixing zones [(32)].
2. (Amended) A micromixer as claimed in Claim 1, [characterized by the fact that] wherein the majority of the feeding chambers [(33)] have parallel main channels [(35)] that intermesh in a comb-like manner, with digital channels [(34)] branching off of said main channels [(35)].

3. (Amended) A micromixer as claimed in Claim 1, [characterized by the fact that] wherein the majority of the feeding chambers [(33)] are surrounded on all sides in the plane of the plate by mixing zones [(32)].
4. (Amended) A micromixer as claimed in Claim 1 [or 3], [characterized by the fact that] wherein the feeding chambers [(33)] are arranged according to the reactants in rows and/or columns in an alternating pattern.
5. (Amended) A micromixer as claimed in Claim 3 [or 4], [characterized by the fact that] wherein the feeding chambers [(33)] have a rectangular outline.
6. (Amended) A micromixer as claimed in Claim 3 [or 4], [characterized by the fact that] wherein the feeding chambers [(33)] have a triangular outline.
7. (Amended) A micromixer as claimed in [one of the] Claim[s] 3 [through 6], [characterized by the fact that] wherein that side of the mixing plate [(20)] facing away from the mixer cells [(30)] is structured and has two storage chambers [(57a,b)] for the reactants;

has parallel channels [(56)] which lead away from the storage chambers [(57a,b)] and run beneath the feeding chambers [(33)], whereby the channels [(56)] for one reactant intermesh in a comb-like manner with the channels [(56)] for the other reactant;

and has penetrations [(12)] leading from the channels [(56)] to the feeding chambers [(33)].

8. (Amended) A micromixer as claimed in [one of the] Claim[s] 3 [through 6], [characterized by the fact that] wherein a first plate [(22)] and below that a second plate [(23)] are arranged below the mixing plate [(20)] to form a storage chamber [(57a,b)] for the two reactants, and said storage chambers [(57a,b)] are connected via supply lines for the respective reactant to the corresponding feeding chambers [(33)], whereby the supply lines for the reactant in the lower storage chamber [(57b)] are hollow bodies [(58)] which carry the reactant through the upper storage chamber [(57a)].
9. (Amended) A micromixer as claimed in [one of the] Claim[s] 3 [through 8], [characterized by the fact that] wherein [it] the micromixer includes an integrated heat exchanger.
10. (Amended) A micromixer as claimed in Claim 9, [characterized by the fact that] wherein hollow bodies [(41)] containing a heating medium or coolant are arranged on the discharge plate [(21)] between the ports [(37)].
11. (Amended) A micromixer as claimed in Claim 9, [characterized by the fact that] wherein a heating medium or coolant is passed through the discharge plate [(21)].
12. (Amended) A micromixer as claimed in Claim 8, [characterized by the fact that] wherein a third chamber [(40)] for a heating medium or coolant is arranged between the mixing plate [(20)] and the two storage chambers [(57a,b)] for reactants, and both reactants are passed in hollow bodies [(58a,b)] through the third chamber [(40)] en route to the feeding chambers [(33)] of the mixing plate [(20)].

13. (Amended) A micromixer array for mixing one or more reactants comprising two or more stacked micromixers [(10a,b)] as claimed in [one or more of the previous claims] Claim 1.
14. (Amended) A micromixer array as claimed in Claim 13, [characterized by the fact that] wherein the micromixers [(10a,b)] are fluidically connected in parallel.
15. (Amended) A micromixer array as claimed in Claim 13, [characterized by the fact that] wherein the micromixers [(10a,b)] are fluidically connected in serial.
16. (Amended) A micromixer array as claimed in Claim 15, [characterized by the fact that] wherein the micromixers [(10a,b)] for mixing three or more reactants are connected in serial, whereby the first micromixer [(10a)] is designed for mixing two reactants to produce a product, and at least one downstream micromixer [(10b)] is designed to mix the third reactant with the intermediate product.
17. (Amended) A micromixer array as claimed in [one of the] Claim[s] 13 [through 16], [characterized by the fact that] wherein there are one or more additional plates [(25, 26a,b)] above, below and/or between adjoining micromixers [(10a,b)] to supply reactant, collect and/or distribute intermediate products and/or to discharge the product.

**IN THE ABSTRACT:**

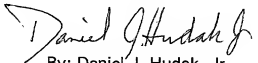
Please replace the original Abstract with the following Abstract:

**ABSTRACT**

Known static micromixers that work according to the principle of multilamination allow for a rapid mixing by diffusion. The invention provides a means for substantially increasing the throughput of known micromixers. To this end, the inventive micromixer [(10)] for mixing two or more reactants comprises microstructures [(31)] that define mixer cells [(30)]. Each of said mixer cells [(30)] is provided with a feeding chamber [(33)] which adjoins at least two groups of digital channels [(34)]. Said channels intermesh with the digital channels [(34)] of the groups adjoining the feeding channels [(33)] in a comb-like manner, thereby producing mixing zones [(32)]. Outlet ports [(37)] are located above said mixing zones [(32)], said outlet ports extending perpendicularly to the digital channels [(34)] and discharging the product. The inventive micromixer is especially useful for the large-scale production of mixtures, dispersions and emulsions.

Respectfully submitted,

HUDAK & SHUNK CO., L.P.A.



By: Daniel J. Hudak, Jr.  
Registration No. 47,669

DJH/lb

7 West Bowery Street  
Suite 808  
Akron, OH 44308-1133  
(330) 535-2220

Attorney Docket No.: FMW-RR-PCT-US (I 839)



MICROMIXER

The invention relates to a micromixer for mixing at least two reactants having penetrations for the supply of the reactants and discharge of the product, having at least one mixing plate with microstructures that define mixer cells, each of said mixer cells having a feeding chamber which adjoins at least one group of digital channels which intermesh in a comb-like manner with the digital channels of a group from the adjoining feeding chamber; and having a discharge plate arranged on the mixing plate, said discharge plate having an outlet port above each mixing zone, said outlet port extending perpendicularly to the digital channels.

Although microfluid components were developed years ago for analytical applications, microengineering techniques have only recently been applied to the development of equipment for chemical synthesis, so-called microreactors. Principle components of such microreactors are mixers and heat exchangers. Conventional static micromixers work according to the principle of multilamination to ensure rapid mixing by diffusion. This is the only mixing mechanism that can be used with laminar flows in microchannels. The creation of alternating laminations by means of geometric parameters allows good mixing in the microscopic range.

The publication Int. Eng. Chem. Res. 1999, 38, 1075-1082, W. Ehrfeld et al., describes a generic micromixer. This single mixer comprises three components: a galvanically and X-ray lithographically structured plate having a mixing zone and two feeding chambers and a two-piece casing in which the plate is set. A means for the supply of reactant and the discharge of the product are provided in the upper section of the casing.

The single mixer has two mixer cells with a common mixing zone. The two fluid reactants are fed into the mixing chambers and split into partial flows in the digital channels. The partial flows of one reactant are not in contact with the partial flows of the other reactant - they are separated from one another by microwalls in the form of ribs. The two reactants first come in contact with one another in the port zone, which is above and perpendicular to the digital channels. The product is discharged from the casing through the ports. The pressure drop in the mixing zone is set by means of the port width.

A significant disadvantage of this single mixer is that its throughput is very limited. With a pressure drop of approx. 1.2 bar, throughput is only 0.8 l/h. Because of this low throughput, use of the single mixer for large-scale chemical production is limited. In an attempt to alleviate this problem, 10 single mixers were arranged in parallel in one casing, with the reactants supplied to the individual micromixers from a common source. The single mixers were arranged in a star configuration, with the supply line for one reactant in the center of the star and the supply lines for the other reactant running around the outside of the star (at the indicated locations). But this measure only resulted in increasing throughput from 0.8 l/h to approx. 3 l/h with a pressure drop of approx. 1.2 bar.

The object of the current invention is to provide a micromixer utilizing the same mixing principle as conventional micromixers but permitting significantly greater throughput at the same pressure drop.

This object is achieved by means of a micromixer for mixing two reactants having openings for the supply of the reactants and/or discharge of the product; microstructures that define at least one mixing plate with mixer cells, whereby each mixer cell has a feeding chamber which adjoins at least one group of digital channels, which digital channels intermesh comb-like with the digital channels of a group from the adjoining feeding chambers; and a discharge plate arranged on the

first plate, said discharge plate having an outlet port above each mixing zone, said outlet port extending perpendicularly to the digital channels, characterized by the fact that each mixer cell has at least two mixing zones.

In the inventive micromixer, the number of microstructures per surface area and thus the throughput is greatly increased. With the inventive micromixer, throughputs of several hundred l/h are achieved with a pressure drop of approx. 1.2 bar. This is many times greater than the throughput of the single mixer and single mixers connected in parallel. The plates of the micromixer can be manufactured of silicon wafers that are structured by means of deep plasma etching and connected to one another by means of anodic bonding, for example. The plates can also be produced by structuring resist, e.g. lithographically or using a laser, with subsequent galvanic shaping. This is particularly well-suited for producing microstructures with large aspect ratios.

The reactants to be mixed in the micromixer can be any combination of gases, fluids, solutions or mixtures thereof. The micromixer is particularly well-suited for the manufacture of mixtures of two fluids or solutions, of fluid-fluid emulsions or gas-fluid dispersions.

The width of the individual digital channels is preferably between 5 and 150  $\mu\text{m}$  and the height of the walls defining the digital channels is preferably between 50  $\mu\text{m}$  and 2 mm. A group of digital channels comprises preferably 3 or more channels. Because of the required pressure drop, the width of the outlet ports is preferably between 10  $\mu\text{m}$  to 1 mm and lesser than the height of the walls defining the digital channels. For complete mixing of the reactants, the width of the outlet ports in the discharge plate must be less than the overlap of the adjoining digital channels in the mixing zone.

There are two preferred embodiments of the inventive micromixer. Similar to the single mixer, the one embodiment has two feeding chambers, each of which has parallel main channels that intermesh in a comb-like manner, however. Branching off of each main channel are digital channels which likewise intermesh in a comb-like manner and form the mixing zones. This configuration increases both the number of mixing zones per mixer cell and the ratio of the surface area of the mixing zones relative to the total surface area of the mixer cell, and thus the throughput per surface area. The corresponding discharge plate has a multitude of parallel ports whose number is equal to the number of mixing zones.

Each feeding chamber preferably has two or more, and more preferably four or more main channels. The digital channels preferably branch off of both sides over the length of the main channels.

This micromixer makes it possible to integrate two or more such mixers into a micromixer system. This is done by arranging one micromixer over the other and configuring the ports for feeding the reactants and discharging the products such that the product of the one micromixer is fed to the other micromixer as the second reactant. This makes it possible to produce products whose reactions occur in two or more stages.

In the aforementioned variant, the micromixers are fluidically connected in serial, i.e. the product of one micromixer is fed to the next micromixer as one of the reactants.

In another embodiment, the micromixers are fluidically connected in parallel, i.e. all micromixers are supplied with the same reactant and the products are discharged together.

Both variants can be advantageously realized by stacking mixing plates and possibly additional supply and/or distribution plates.

In the second preferred embodiment of the inventive micromixer, mixing zones are arranged on all sides of the feeding chambers in the plane of the plates. Only those feeding chambers at the edge of the plane of the plates have mixing zones on only one or two sides. This increases the ratio of mixing zone area to mixer cell area and thus increases the throughput per surface area. The object of the invention is to arrange as many mixer cells as possible on the mixing plate. It is advantageous for the mixing plate to have 10 or more mixer cells per square centimeter.

It is advantageous if the feeding chambers are arranged according to the reactants in rows and/or columns in an alternating pattern. This further reduces the percentage of unutilized surface area. It is particularly advantageous if the feeding chambers are arranged in 4 or more rows and in 4 or more columns.

An optimal utilization of the surface area is achieved if the feeding chambers have either a rectangular or triangular outline, with squares or equilateral triangles preferred. The ports of the corresponding discharge plates are located along the edges of the squares or equilateral triangles, which are arranged so as to completely cover the discharge plate.

Two approaches have proven to be advantageous for the supply of reactants to the mixing plate. The first approach is to structure that side of the mixing plate facing away from the mixer cells. This creates a storage chamber for each reactant. Parallel channels lead out from each storage chamber and run beneath the feeding chambers. It is important that the channels for the two reactants intermesh in a comb-like manner so that the feeding chambers with one reactant are surrounded by the feeding chambers with the other reactant. Each channel has penetrations beneath the feeding chambers, which penetrations lead into the feeding chambers

and through which the reactant can flow into the feeding chambers. It is not mandatory that the mixing plate be a monobody construction, one plate can be manufactured with the microstructures and another plate can have the feed structures, with both plates joined by means of anodic bonding, for example, to form a mixing plate.

The other approach for supplying the reactants to the mixing plate is to arrange two additional plates beneath the mixing plate. The one plate together with the mixing plate form a storage chamber for the one reactant and the other plate together with the first plate forms a storage chamber for the second reactant. The reactant in the storage chamber adjoining the mixing plate passed directly into the corresponding feeding chambers via penetrations in the mixing plate. The first additional plate is provided with penetrations for the supply of the other reactant, through which penetrations hollow bodies that also pass through penetrations in the mixing plate and empty into the corresponding feeding chambers are run. The second reactant flows from the second storage chamber into the feeding chambers through these hollow bodies. The flow resistance in these feeding chambers is particularly low so that the reactants are very evenly distributed between the individual feeding chambers. However, this requires more space than does the supply via structures in the back side of the mixing plate.

Of particular importance for the use of the micromixer as a microreactor is the integration of a heat exchanger in the micromixer, if necessary. The heat exchanger can be integrated into the micromixer in a variety of ways. The following solutions are preferred: for reactions or mixtures with little heat tone, it is sufficient to arrange hollow bodies on the discharge plate between the ports, through which hollow bodies a heating medium or coolant flows.

With greater heat tone, the discharge plate can be a two-piece construction in which two overlapping cover plates are arranged at some distance from one

another to form a chamber that is filled with either a heating medium or coolant. To pass the product through the heating medium or coolant, flattened hollow bodies analogous to those in the example described above for the supply of reactant and having an outline corresponding to that of the ports are arranged in the ports of both parts of the discharge plate. This variant provides a particularly homogenous distribution of heat. In another embodiment, the discharge plate can be designed with sufficient thickness to include channels perpendicular to the ports, through which channels the heating medium or coolant can flow.

Under certain circumstances, it may be necessary to bring the reactants to a certain temperature. In these cases, it is advantageous to use a micromixer in which the reactants are supplied through storage chambers formed by two plates. To attemporate the reactants, an additional plate is inserted between the first plate and the mixing plate so that another storage chamber is formed between the mixing plate and this additional plate. The heating medium or coolant is fed into this storage chamber. Both reactants must be passed through the heat exchanger chamber in hollow bodies, e.g. tubes. The hollow bodies must be secured in the plates so as to obtain a tight seal. These can be welded, soldered/brazed, diffusion welded, pressed in or bent on.

The current invention is described in greater detail below with reference to the attached drawings:

Fig. 1a      a first embodiment of a mixing plate

Fig. 1b      a section from the mixing plate in Fig. 1a

Fig. 1c      the discharge plate corresponding to the mixing plate in Fig. 1a

- Fig. 2 a mixer system
- Fig. 3a a second embodiment of a mixing plate and an associated discharge plate
- Fig. 3b an area from Fig. 3a
- Fig. 3c a section through the area in Fig. 3b along the line A-A
- Fig. 4 a third embodiment of a mixing plate
- Fig. 5a a first embodiment of the reactant supply
- Fig. 5b a section through Fig. 5a along the line B-B
- Fig. 6 a second embodiment of the reactant supply
- Fig. 7 a first embodiment of an integrated heat exchanger
- Fig. 8 a second embodiment of an integrated heat exchanger
- Fig. 9 a third embodiment of an integrated heat exchanger
- Fig. 10 a fourth embodiment of an integrated heat exchanger
- Fig. 11 an exploded view of a micromixer

Fig. 1a shows a first embodiment of a mixing plate 20. This mixing plate 20 has two feeding chambers 33a and 33b for the reactants A,B. Both feeding chambers



33a,b branch into four primary channels 35a,b. Microstructures 31 defining the mixing zones 32 between the main channels 35 for the reactants A and B are located on both sides along the main channels 35a,b. The main channels 35a,b intermesh in a comb-like manner. The feeding chambers 33a,b together with the mixing zones 32 each form a mixer cell 30a and 30b.

The mixing plate 20 also has recesses 14 by means of which the individual plates comprising the micromixer are screwed together.

Fig. 1b is an enlarged view of that section of Fig. 1a marked with a broken line. One can see that digital channels 34 branch off from the main channels 35a,b. These digital channels are separated from one another by microstructures in the form of thin walls 36a. These walls 36a are corrugated and meandering to increase their mechanical stability. This is necessary as these walls 36a and also the digital channels 34 are only approximately 40  $\mu\text{m}$  wide. In contrast, the digital channels 34 are approximately 300  $\mu\text{m}$  long. One also can see that wider walls 36b separate the main channels 35a,b and also the feeding chambers 33a,b from one another. The reactants A and B first come into contact with one another as they pass through a port in a discharge plate 21 (cf. Fig. 1c) arranged above and extending perpendicularly to the digital channels 34 and over the entire mixing zone 32. The port is approximately 80  $\mu\text{m}$  wide.

Fig. 1c shows the discharge plate 21 corresponding to the mixing plate in Fig. 1a. The ports 37 are arranged in a series of parallel curves. The number of ports corresponds to the number of mixing zones in the mixing plate 20 below and the ports are arranged such that they extend perpendicularly to the digital channels and over the entire length of the respective mixing zones 32. Furthermore, the discharge plate 21 also has recesses 14 for bolting the micromixer together as well as penetrations 12 through which the reactants or also the product can flow.

Fig. 2 shows a mixer system. This mixer system is created by arranging two micromixers per the example in Figs. 1a-c one above the other. At the bottom is a cover plate 26a with recesses 14 for screws and two penetrations 12a,b through which the reactants A and B are supplied. (Reactant A through the front right penetration 12a and reactant B through the rear left penetration 12b.). The direction of flow is from bottom to top.

Above that is a first mixing plate 20a. In addition to the two feeding chambers 33a and 33b, the main channels 35 and the mixing zones 32, the mixing plate 20a has two penetrations 12c,d arranged in two diagonally-opposed corners of the mixing plate 20a. The feeding chambers 33a and 33b are designed such that they are connected to the penetrations 12a,b in the bottom cover plate 26a, through which penetrations the reactants A,B are fed into to the feeding chambers 33a,b.

Above the first mixing plate 20a is a first discharge plate 21a with ports 37. The intermediate product C, which is a product of A and B, is discharged through these ports 37, collected in a collecting chamber 39 formed by plates 27a and 25 arranged above the discharge plate 21a, and directed to the penetration 12c.

The intermediate product C is fed via the intermediate plate 25 into the feeding chamber 33c of the second mixing plate 20b as reactant for the second reaction. Reactant D is fed into the second feeding chamber 33d of the mixing plate 20b via penetrations 12d that form a channel through the front left edge area of the mixer system. Another discharge plate 21b and a collecting plate 27b are arranged above the second mixing plate 20b.

The collecting plate 27b together with the top cover plate 26b forms a collecting chamber 39 for the product of C and D, which is directed to the upper right front penetration 12a' and can exit via the top cover plate 26b.

Reactant D is passed through the front left penetrations 12d; reactant B is passed through the rear left penetrations 12b; the intermediate product C is passed through the rear right penetrations 12c; reactant A is passed through the lower front right penetrations 12a and the end product is passed through the upper right front penetrations 12a'. The intermediate plate 25 forms the boundary between the bottom micromixer 10a and the top micromixer 10b.

Fig. 3a shows an additional embodiment of a mixing plate 20 and the corresponding discharge plate 21. The feeding chambers 33 are square and have mixing zones 32 on each of the four sides. A mixer cell 30 comprises a feeding chamber 33 and four mixing zones 32. Each of the feeding chambers 33 has its own penetration 12 for the supply of a reactant. The feeding chambers 33 are arranged equidistant from one another in rows 60 and columns 61 so that a feeding chamber 33a for one reactant is always surrounded by four feeding chambers 33b for the other reactant. This arrangement of feeding chambers 33 in a regular grid is reflected in the arrangement of the ports 27 in a discharge plate 21 above the mixing plate 20. The ports 37 run along the edges of squares and form a regular box pattern.

Fig. 3b shows an enlarged view of that area of Fig. 3a indicated by a broken line. The digital channels 34 that make up the mixing zones 32 can be seen more clearly in this enlarged excerpt.

The section through the area shown in Fig. 3b along the line IIIc-IIIc is shown in Fig. 3c. The penetrations 12 through which the reactants are fed into the feeding chambers 33 can be clearly seen here. The digital channels 34 arranged around the

feeding chamber and the walls 36 defining these digital channels 34 can also be seen.

The individual digital channels 34 are between 5 and 150  $\mu\text{m}$  wide and the walls 36 defining the digital channels are between 50  $\mu\text{m}$  and 2 mm high. Because of the pressure drop required, the width of the outlet ports 37 is preferably less than the height of the walls 36 defining the digital channels 34. Furthermore, the width of the outlet ports 37 in the discharge plate 21 must be less than the overlap between adjacent digital channels 34 in the mixing zone 32 to achieve complete mixing of the reactants.

A modification of the embodiment described above is shown in Fig. 4. Here the feeding chambers 33 are triangular with three sides of equal length. Once again there is a mixing zone 32 on all sides of the feeding chamber 33, and the feeding chambers 33 themselves are arranged at the corners of even, adjacent hexagons. The feeding chamber 33a for one reactant is surrounded by three feeding chambers 33b for the other reactant.

Fig. 5a shows a first example for the reactant supply. This is a structured plate attached to the back of the mixing plate, e.g. by means of anodic bonding. A storage chamber 57a for reactant A and a storage chamber 57b for reactant B are found on two opposing sides of the plate. Channels 56a,b lead out from these storage chambers 57a,b. These channels 56a,b, intermesh in a comb-like manner. They run beneath the feeding chamber of the mixing chamber and are parallel to one another. Penetrations 12a,b aligned with corresponding penetrations 12a,b of the mixing plate lead away from each channel 56a,b. The penetrations 12a,b connect the feeding chambers of the mixing plates to the channels 56a,b and thus also to the storage chambers 57a,b. The reactants A,B are supplied to the feeding chambers via this connection. These structures can be produced using deep plasma etching of silicon, for example.

The section along the line Vb-Vb is shown in Fig. 5b. The channels 56a,b are shown again. Only the penetrations 12a can be seen due to the orientation of the section.

Another embodiment of the reactant supply is shown in Fig. 6. All that is shown of the mixing plate 20 are the penetrations 12a,b. Below the mixing plate 20 is the first additional plate 22, below which a second additional plate 23 is arranged. The three plates 20,22,23 are arranged parallel to and at some distance from one another so that a storage chamber 57a for reactant A is formed between the mixing plate 20 and the first additional plate 22, and the first additional plate 22 and the second additional plate 23 form a storage chamber 57b for reactant B. Reactant A is supplied to the feeding chambers of the mixing plate 20 through the penetrations 12a, which directly connect the feeding chambers of the mixing plate 20 and the storage chamber 57a for reactant A. In contrast, reactant B must be passed through the storage chamber 57a. The first additional plate 22 is therefore provided with recesses arranged below the penetrations 12b of the mixing plate 20. Hollow bodies in the form of tubes 58 are passed through the penetrations 12b and the recesses in the first additional plate 22. These tubes 58 form the connection between the storage chamber 47b and the feeding chambers for reactant B.

Fig. 7 shows a first embodiment for the integration of a heat exchanger in the micromixer. In this example, the product is heated or cooled by means of hollow bodies in the form of tubes 41 that are arranged on the discharge plate 21 between the ports 37 and extend over the entire length of the discharge plate 21. A coolant or heating medium is passed through these tubes 41.

Fig. 8 shows a second embodiment for the integration of a heat exchanger. In this embodiment, the product is again heated or cooled. The discharge plate comprises

two individual plates 21a and 21b. These are arranged parallel to and at some distance from one another to form a chamber 40 for holding a heating medium or coolant. Both individual plates 21a and 21b are provided with discharge ports 37. The product is transported from one side of the cover plate [sic] 21 to the other by means of flattened hollow bodies 41a arranged in the ports to form a connection from one side of the discharge plate 21 to the other.

Fig. 9 shows a third embodiment for heating or cooling the medium. The discharge plate 21 is again a two-piece construction, with an upper slotted plate 21a and a very much thicker lower slotted plate 21b. In addition to the ports 37, the lower, thicker plate 21b also has open-ended slots 42 for holding the coolant or heating medium which extend perpendicular to the ports 37 for the product. It is advantageous if a material with good thermoconducting properties is used for the manufacture of the lower plate 21b.

In some cases, it can also be desirable to preheat or cool the reactants. An embodiment enabling this is shown in Fig. 10. This is a micromixer with storage chambers 57a,b for the supply of reactants comprising two additional plates 22, 23. A third additional plate 24 is arranged between the first additional plate 22 and the mixing plate 20. This creates an additional chamber 40 between the mixing plate 20 and the third additional plate 24, in which chamber 40 a heating medium or coolant is found. Because both reactants A and B must be passed through this heat exchanger chamber 40 en route to the feeding chambers 33a,b, in the mixing plate 20, the third additional plate 24 has recesses arranged beneath the penetrations 12a,b of the mixing plate 20. Through these recesses pass hollow bodies in the form of tubes 58a,b which empty into the penetrations 12a,b of the mixing plate 20 and are connected at the other end to either storage chamber 57a or storage chamber 57b. The reactants A,B are evenly attemporated as they pass from the respective storage chamber 57a,b to the feeding chamber 33a,b for the respective reactant A,B.

Fig. 11 is an exploded view of a micromixer. This micromixer 10 comprises a casing 11 having two penetrations 12 for each reactant A,B. The casing 11 also has recesses 14 for seating screws 13. At the bottom of the casing is an intermediate plate 25 with two penetrations 12 for each reactant. A mixing plate 20 structured on both sides is arranged above the intermediate plate 25. The bottom of the mixing plate is provided with microstructures for the supply of the reactants (cf. Fig. 5a). Mixer cells with square feeding chambers are arranged on the top of the mixer plate 20. A slotted discharge plate 21 is arranged above the mixing plate 20. Above the discharge plate is a cover plate 26 having an opening 12 for the product. The cover plate 26 also has recesses 14 for seating screws 13. These screws 13 are used to securely screw the micromixer 10 together.

With a micromixer 10 of this type configured with approximately 1500 feeding chambers per mixing plate, a surface area of 45 x 45 mm and a volumetric flow of 700 l/h with a pressure drop of approximately 1 bar can be achieved.

# Reference Numbers

10	micromixer
11	casing
12	penetration
13	screw
14	recess
20	mixing plate
21	discharge plate
22	first additional plate
23	second additional plate
24	third additional plate
25	intermediate plate
26	cover plate
27	collecting plate
30	mixer cell
31	microstructure
32	mixing zone
33	feeding chamber
34	digital channel
35	main channel
36	wall
37	outlet port
39	collecting chamber
40	heat exchanger chamber
41	hollow body
41a	flattened hollow body
42	heat exchanger slot
56	channel
57	storage chamber





**Claims**

1. Micromixer (10) for mixing at least two reactants having penetrations (12) for the supply of the reactants and/or the discharge of the product; having at least one mixing plate (20) with microstructures (31) that define mixer cells (30), each of said mixer cells (30) having a feeding chamber (33) which adjoins at least one group of digital channels (34) which intermesh in a comb-like manner with the digital channels (34) of a group from the adjoining feeding chambers (33) to form a mixing zone (32); and having a discharge plate (21) arranged on the mixing plate (20), said discharge plate (21) having an outlet port (37) above each mixing zone (32), said outlet port (37) extending perpendicularly to the digital channels (34), **characterized by the fact that each mixer cell (30) has at least two mixing zones (32).**
2. Micromixer as claimed in Claim 1, characterized by the fact that the majority of the feeding chambers (33) have parallel main channels (35) that intermesh in a comb-like manner, with digital channels (34) branching off of said main channels (35).
3. Micromixer as claimed in Claim 1, characterized by the fact that the majority of the feeding chambers (33) are surrounded on all sides in the plane of the plate by mixing zones (32).
4. Micromixer as claimed in Claim 1 or 3, characterized by the fact that the feeding chambers (33) are arranged according to the reactants in rows and/or columns in an alternating pattern.
5. Micromixer as claimed in Claim 3 or 4, characterized by the fact that the feeding chambers (33) have a rectangular outline.

6. Micromixer as claimed in Claim 3 or 4, characterized by the fact that the feeding chambers (33) have a triangular outline.
7. Micromixer as claimed in one of the Claims 3 through 6, characterized by the fact that that side of the mixing plate (20) facing away from the mixer cells (30) is structured and has two storage chambers (57a,b) for the reactants;
 

has parallel channels (56) which lead away from the storage chambers (57a,b) and run beneath the feeding chambers (33), whereby the channels (56) for one reactant intermesh in a comb-like manner with the channels (56) for the other reactant;

and has penetrations (12) leading from the channels (56) to the feeding chambers (33).
8. Micromixer as claimed in one of the Claims 3 through 6, characterized by the fact that a first plate (22) and below that a second plate (23) are arranged below the mixing plate (20) to form a storage chamber (57a,b) for the two reactants, and said storage chambers (57a,b) are connected via supply lines for the respective reactant to the corresponding feeding chambers (33), whereby the supply lines for the reactant in the lower storage chamber (57b) are hollow bodies (58) which carry the reactant through the upper storage chamber (57a).
9. Micromixer as claimed in one of the Claims 3 through 8, characterized by the fact that it includes an integrated heat exchanger.
10. Micromixer as claimed in Claim 9, characterized by the fact that hollow bodies (41) containing a heating medium or coolant are arranged on the discharge plate (21) between the ports (37).

11. Micromixer as claimed in Claim 9, characterized by the fact that a heating medium or coolant is passed through the discharge plate (21).
12. Micromixer as claimed in Claim 8, characterized by the fact that a third chamber (40) for a heating medium or coolant is arranged between the mixing plate (20) and the two storage chambers (57a,b) for reactants, and both reactants are passed in hollow bodies (58a,b) through the third chamber (40) en route to the feeding chambers (33) of the mixing plate (20).
13. Micromixer array for mixing one or more reactants comprising two or more stacked micromixers (10a,b) as claimed in one or more of the previous claims.
14. Micromixer array as claimed in Claim 13, characterized by the fact that the micromixers (10a,b) are fluidically connected in parallel.
15. Micromixer array as claimed in Claim 13, characterized by the fact that the micromixers (10a,b) are fluidically connected in serial.
16. Micromixer array as claimed in Claim 15, characterized by the fact that the micromixers (10a,b) for mixing three or more reactants are connected in serial, whereby the first micromixer (10a) is designed for mixing two reactants to produce a product, and at least one downstream micromixer (10b) is designed to mix the third reactant with the intermediate product.
17. Micromixer array as claimed in one of the Claims 13 through 16, characterized by the fact that there are one or more additional plates (25, 26a,b) above, below and/or between adjoining micromixers (10a,b) to supply reactant, collect and/or distribute intermediate products and/or to discharge the product.

**ABSTRACT**

Known static micromixers that work according to the principle of multilamination allow for a rapid mixing by diffusion. The invention provides a means for substantially increasing the throughput of known micromixers. To this end, the inventive micromixer (10) for mixing two or more reactants comprises microstructures (31) that define mixer cells (30). Each of said mixer cells (30) is provided with a feeding chamber (33) which adjoins at least two groups of digital channels (34). Said channels intermesh with the digital channels (34) of the groups adjoining the feeding channels (33) in a comb-like manner, thereby producing mixing zones (32). Outlet ports (33) [sic - Translator's note: The correct number is 37] are located above said mixing zones (32), said outlet ports extending perpendicularly to the digital channels (34) and discharging the product. The inventive micromixer is especially useful for the large-scale production of mixtures, dispersions and emulsions.

10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65  
66  
67  
68  
69  
70  
71  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81  
82  
83  
84  
85  
86  
87  
88  
89  
90  
91  
92  
93  
94  
95  
96  
97  
98  
99  
100  
101  
102  
103  
104  
105  
106  
107  
108  
109  
110  
111  
112  
113  
114  
115  
116  
117  
118  
119  
120  
121  
122  
123  
124  
125  
126  
127  
128  
129  
130  
131  
132  
133  
134  
135  
136  
137  
138  
139  
140  
141  
142  
143  
144  
145  
146  
147  
148  
149  
150  
151  
152  
153  
154  
155  
156  
157  
158  
159  
160  
161  
162  
163  
164  
165  
166  
167  
168  
169  
170  
171  
172  
173  
174  
175  
176  
177  
178  
179  
180  
181  
182  
183  
184  
185  
186  
187  
188  
189  
190  
191  
192  
193  
194  
195  
196  
197  
198  
199  
200  
201  
202  
203  
204  
205  
206  
207  
208  
209  
210  
211  
212  
213  
214  
215  
216  
217  
218  
219  
220  
221  
222  
223  
224  
225  
226  
227  
228  
229  
230  
231  
232  
233  
234  
235  
236  
237  
238  
239  
240  
241  
242  
243  
244  
245  
246  
247  
248  
249  
250  
251  
252  
253  
254  
255  
256  
257  
258  
259  
260  
261  
262  
263  
264  
265  
266  
267  
268  
269  
270  
271  
272  
273  
274  
275  
276  
277  
278  
279  
280  
281  
282  
283  
284  
285  
286  
287  
288  
289  
290  
291  
292  
293  
294  
295  
296  
297  
298  
299  
300  
301  
302  
303  
304  
305  
306  
307  
308  
309  
310  
311  
312  
313  
314  
315  
316  
317  
318  
319  
320  
321  
322  
323  
324  
325  
326  
327  
328  
329  
330  
331  
332  
333  
334  
335  
336  
337  
338  
339  
340  
341  
342  
343  
344  
345  
346  
347  
348  
349  
350  
351  
352  
353  
354  
355  
356  
357  
358  
359  
360  
361  
362  
363  
364  
365  
366  
367  
368  
369  
370  
371  
372  
373  
374  
375  
376  
377  
378  
379  
380  
381  
382  
383  
384  
385  
386  
387  
388  
389  
390  
391  
392  
393  
394  
395  
396  
397  
398  
399  
400  
401  
402  
403  
404  
405  
406  
407  
408  
409  
410  
411  
412  
413  
414  
415  
416  
417  
418  
419  
420  
421  
422  
423  
424  
425  
426  
427  
428  
429  
430  
431  
432  
433  
434  
435  
436  
437  
438  
439  
440  
441  
442  
443  
444  
445  
446  
447  
448  
449  
450  
451  
452  
453  
454  
455  
456  
457  
458  
459  
460  
461  
462  
463  
464  
465  
466  
467  
468  
469  
470  
471  
472  
473  
474  
475  
476  
477  
478  
479  
480  
481  
482  
483  
484  
485  
486  
487  
488  
489  
490  
491  
492  
493  
494  
495  
496  
497  
498  
499  
500  
501  
502  
503  
504  
505  
506  
507  
508  
509  
510  
511  
512  
513  
514  
515  
516  
517  
518  
519  
520  
521  
522  
523  
524  
525  
526  
527  
528  
529  
530  
531  
532  
533  
534  
535  
536  
537  
538  
539  
540  
541  
542  
543  
544  
545  
546  
547  
548  
549  
550  
551  
552  
553  
554  
555  
556  
557  
558  
559  
560  
561  
562  
563  
564  
565  
566  
567  
568  
569  
570  
571  
572  
573  
574  
575  
576  
577  
578  
579  
580  
581  
582  
583  
584  
585  
586  
587  
588  
589  
590  
591  
592  
593  
594  
595  
596  
597  
598  
599  
600  
601  
602  
603  
604  
605  
606  
607  
608  
609  
610  
611  
612  
613  
614  
615  
616  
617  
618  
619  
620  
621  
622  
623  
624  
625  
626  
627  
628  
629  
630  
631  
632  
633  
634  
635  
636  
637  
638  
639  
640  
641  
642  
643  
644  
645  
646  
647  
648  
649  
650  
651  
652  
653  
654  
655  
656  
657  
658  
659  
660  
661  
662  
663  
664  
665  
666  
667  
668  
669  
670  
671  
672  
673  
674  
675  
676  
677  
678  
679  
680  
681  
682  
683  
684  
685  
686  
687  
688  
689  
690  
691  
692  
693  
694  
695  
696  
697  
698  
699  
700  
701  
702  
703  
704  
705  
706  
707  
708  
709  
710  
711  
712  
713  
714  
715  
716  
717  
718  
719  
720  
721  
722  
723  
724  
725  
726  
727  
728  
729  
730  
731  
732  
733  
734  
735  
736  
737  
738  
739  
740  
741  
742  
743  
744  
745  
746  
747  
748  
749  
750  
751  
752  
753  
754  
755  
756  
757  
758  
759  
760  
761  
762  
763  
764  
765  
766  
767  
768  
769  
770  
771  
772  
773  
774  
775  
776  
777  
778  
779  
780  
781  
782  
783  
784  
785  
786  
787  
788  
789  
790  
791  
792  
793  
794  
795  
796  
797  
798  
799  
800  
801  
802  
803  
804  
805  
806  
807  
808  
809  
810  
811  
812  
813  
814  
815  
816  
817  
818  
819  
820  
821  
822  
823  
824  
825  
826  
827  
828  
829  
830  
831  
832  
833  
834  
835  
836  
837  
838  
839  
840  
841  
842  
843  
844  
845  
846  
847  
848  
849  
850  
851  
852  
853  
854  
855  
856  
857  
858  
859  
860  
861  
862  
863  
864  
865  
866  
867  
868  
869  
870  
871  
872  
873  
874  
875  
876  
877  
878  
879  
880  
881  
882  
883  
884  
885  
886  
887  
888  
889  
890  
891  
892  
893  
894  
895  
896  
897  
898  
899  
900  
901  
902  
903  
904  
905  
906  
907  
908  
909  
910  
911  
912  
913  
914  
915  
916  
917  
918  
919  
920  
921  
922  
923  
924  
925  
926  
927  
928  
929  
930  
931  
932  
933  
934  
935  
936  
937  
938  
939  
940  
941  
942  
943  
944  
945  
946  
947  
948  
949  
950  
951  
952  
953  
954  
955  
956  
957  
958  
959  
960  
961  
962  
963  
964  
965  
966  
967  
968  
969  
970  
971  
972  
973  
974  
975  
976  
977  
978  
979  
980  
981  
982  
983  
984  
985  
986  
987  
988  
989  
990  
991  
992  
993  
994  
995  
996  
997  
998  
999  
1000  
1001  
1002  
1003  
1004  
1005  
1006  
1007  
1008  
1009  
1010  
1011  
1012  
1013  
1014  
1015  
1016  
1017  
1018  
1019  
1020  
1021  
1022  
1023  
1024  
1025  
1026  
1027  
1028  
1029  
1030  
1031  
1032  
1033  
1034  
1035  
1036  
1037  
1038  
1039  
1040  
1041  
1042  
1043  
1044  
1045  
1046  
1047  
1048  
1049  
1050  
1051  
1052  
1053  
1054  
1055  
1056  
1057  
1058  
1059  
1060  
1061  
1062  
1063  
1064  
1065  
1066  
1067  
1068  
1069  
1070  
1071  
1072  
1073  
1074  
1075  
1076  
1077  
1078  
1079  
1080  
1081  
1082  
1083  
1084  
1085  
1086  
1087  
1088  
1089  
1090  
1091  
1092  
1093  
1094  
1095  
1096  
1097  
1098  
1099  
1100  
1101  
1102  
1103  
1104  
1105  
1106  
1107  
1108  
1109  
1110  
1111  
1112  
1113  
1114  
1115  
1116  
1117  
1118  
1119  
1120  
1121  
1122  
1123  
1124  
1125  
1126  
1127  
1128  
1129  
1130  
1131  
1132  
1133  
1134  
1135  
1136  
1137  
1138  
1139  
1140  
1141  
1142  
1143  
1144  
1145  
1146  
1147  
1148  
1149  
1150  
1151  
1152  
1153  
1154  
1155  
1156  
1157  
1158  
1159  
1160  
1161  
1162  
1163  
1164  
1165  
1166  
1167  
1168  
1169  
1170  
1171  
1172  
1173  
1174  
1175  
1176  
1177  
1178  
1179  
1180  
1181  
1182  
1183  
1184  
1185  
1186  
1187  
1188  
1189  
1190  
1191  
1192  
1193  
1194  
1195  
1196  
1197  
1198  
1199  
1200  
1201  
1202  
1203  
1204  
1205  
1206  
1207  
1208  
1209  
1210  
1211  
1212  
1213  
1214  
1215  
1216  
1217  
1218  
1219  
1220  
1221  
1222  
1223  
1224  
1225  
1226  
1227  
1228  
1229  
1230  
1231  
1232  
1233  
1234  
1235  
1236  
1237  
1238  
1239  
1240  
1241  
1242  
1243  
1244  
1245  
1246  
1247  
1248  
1249  
1250  
1251  
1252  
1253  
1254  
1255  
1256  
1257  
1258  
1259  
1260  
1261  
1262  
1263  
1264  
1265  
1266  
1267  
1268  
1269  
1270  
1271  
1272  
1273  
1274  
1275  
1276  
1277  
1278  
1279  
1280  
1281  
1282  
1283  
1284  
1285  
1286  
1287  
1288  
1289  
1290  
1291  
1292  
1293  
1294  
1295  
1296  
1297  
1298  
1299  
1300  
1301  
1302  
1303  
1304  
1305  
1306  
1307  
1308  
1309  
1310  
1311  
1312  
1313  
1314  
1315  
1316  
1317  
1318  
1319  
1320  
1321  
1322  
1323  
1324  
1325  
1326  
1327  
1328  
1329  
1330  
1331  
1332  
1333  
1334  
1335  
1336  
1337  
1338  
1339  
1340  
1341  
1342  
1343  
1344  
1345  
1346  
1347  
1348  
1349  
1350  
1351  
1352  
1353  
1354  
1355  
1356  
1357  
1358  
1359  
1360  
1361  
1362  
1363  
1364  
1365  
1366  
1367  
1368  
1369  
1370  
1371  
1372  
1373  
1374  
1375  
1376  
1377  
1378  
1379  
1380  
1381  
1382  
1383  
1384  
1385  
1386  
1387  
1388  
1389  
1390  
1391  
1392  
1393  
1394  
1395  
1396  
1397  
1398  
1399  
1400  
1401  
1402  
1403  
1404  
1405  
1406  
1407  
1408  
1409  
1410  
1411  
1412  
1413  
1414  
1415  
1416  
1417  
1418  
1419  
1420  
1421  
1422  
1423  
1424  
1425  
1426  
1427  
1428  
1429  
1430  
1431  
1432  
1433  
1434  
1435  
1436  
1437  
1438  
1439  
1440  
1441  
1442  
1443  
1444  
1445  
1446  
1447  
1448  
1449  
1450  
1451  
1452  
1453  
1454  
1455  
1456  
1457  
1458  
1459  
1460  
1461  
1462  
1463  
1464  
1465  
1466  
1467  
1468  
1469  
1470  
1471  
1472  
1473  
1474  
1475  
1476  
1477  
1478  
1479  
1480  
1481  
1482  
1483  
1484  
1485  
1486  
1487  
1488  
1489  
1490  
1491  
1492  
1493  
1494  
1495  
1496  
1497  
1498  
1499  
1500  
1501  
1502  
1503  
1504  
1505  
1506  
1507  
1508  
1509  
1510  
1511  
1512  
1513  
1514  
1515  
1516  
1517  
1518  
1519  
1520  
1521  
1522  
1523  
1524  
1525  
1526  
1527  
1528  
1529  
1530  
1531  
1532  
1533  
1534  
1535  
1536  
1537  
1538  
1539  
1540  
1541  
1542  
1543  
1544  
1545  
1546  
1547  
1548  
1549  
1550  
1551  
1552  
1553  
1554  
1555  
1556  
1557  
1558  
1559  
1560  
1561  
1562  
1563  
1564  
1565  
1566  
1567  
1568  
1569  
1570  
1571  
1572  
1573  
1574  
1575  
1576  
1577  
1578  
1579  
1580  
1581  
1582  
1583  
1584  
1585  
1586  
1587  
1588  
1589  
1590  
1591  
1592  
1593  
1594  
1595  
1596  
1597  
1598  
1599  
1600  
1601  
1602  
1603  
1604  
1605  
1606  
1607  
1608  
1609  
1610  
1611  
1612  
1613  
1614  
1615  
1616  
1617  
1618  
1619  
1620  
1621  
1622  
1623  
1624  
1625  
1626  
1627  
1628  
1629  
1630  
1631  
1632  
1633  
1634  
1635  
1636  
1637  
1638  
1639  
1640  
1641  
1642  
1643  
1644  
1645  
1646  
1647  
1648  
1649  
1650  
1651  
1652  
1653  
1654  
1655  
1656  
1657  
1658  
1659  
1660  
1661  
1662  
1663  
1664  
1665  
1666  
1667  
1668  
1669  
1670  
1671  
1672  
1673  
1674  
1675  
1676  
1677  
1678  
1679  
1680  
1681  
1682  
1683  
1684  
1685  
1686  
1687  
1688  
1689  
1690  
1691  
1692  
1693  
1694  
1695  
1696  
1697  
1698  
1699  
1700  
1701  
1702  
1703  
1704  
1705  
1706  
1707  
1708  
1709  
1710  
1711  
1712  
1713  
1714  
1715  
1716  
1717  
1718  
1719  
1720  
1721  
1722  
1723  
1724  
1725  
1726  
1727  
1728  
1729  
1730  
1731  
1732  
1733  
1734  
1735  
1736  
1737  
1738  
1739  
1740  
1741  
1742  
1743  
1744  
1745  
1746  
1747  
1748  
1749  
1750  
1751  
1752  
1753  
1754  
1755  
1756  
1757  
1758  
1759  
1760  
1761  
1762  
1763  
1764  
1765  
1766  
1767  
1768  
1769  
1770  
1771  
1772  
1773  
1774  
1775  
1776  
1777  
1778  
1779  
1780  
1781  
1782  
1783  
1784  
1785  
1786  
1787  
1788  
1789  
1790  
1791  
1792  
1793  
1794  
1795  
1796  
1797  
1798  
1799  
1800  
1801  
1802  
1803  
1804  
1805  
1806  
1807  
1808  
1809  
1810  
1811  
1812  
1813  
1814  
1815  
1816  
1817  
1818  
1819  
1820  
1821  
1822  
1823  
1824  
1825  
1826  
1827  
1828  
1829  
1830  
1831  
1832  
1833  
1834  
1835  
1836  
1837  
1838  
1839  
1840  
1841  
1842  
1843  
1844  
1845  
1846  
1847  
1848  
1849  
1850  
1851  
1852  
1853  
1854  
1855  
1856  
1857  
1858  
1859  
1860  
1861  
1862  
1863  
1864  
1865  
1866  
1867  
1868  
1869  
1870  
1871  
1872  
1873  
1874  
1875  
1876  
1877  
1878  
1879  
1880  
1881  
1882  
1883  
1884  
1885  
1886  
1887  
1888  
1889  
1890  
1891  
1892  
1893  
1894  
1895  
1896  
1897  
1898  
1899  
1900  
1901  
1902  
1903  
1904  
1905  
1906  
1907  
1908  
1909  
1910  
1911  
1912  
1913  
1914  
1915  
1916  
1917  
1918  
1919  
1920  
1921  
1922  
1923  
1924  
1925  
1926  
1927  
1928  
1929  
1930  
1931  
1932  
1933  
1934  
1935  
1936  
1937  
1938  
1939  
1940  
1941  
1942  
1943  
1944  
1945  
1946  
1947  
1948  
1949  
1950  
1951  
1952  
1953  
1954  
1955  
1956  
1957  
1958  
1959  
1960  
1961  
1962  
1963  
1964  
1965  
1966  
1967  
1968  
1969  
1970  
1971  
1972  
1973  
1974  
1975  
1976  
1977  
1978  
1979  
1980  
1981  
1982  
1983  
1984  
1985  
1986  
1987  
1988  
1989  
1990  
1991  
1992  
1993  
1994  
1995  
1996  
1997  
1998  
1999  
2000  
2001  
2002  
2003  
2004  
2005  
2006  
2007  
2008  
2009  
2010  
2011  
2012  
2013  
2014  
2015  
2016  
2017  
2018  
2019  
2020  
2021  
2022  
2023  
2024  
2025  
2026  
2027  
2028  
2029  
2030  
2031  
2032  
2033  
2034  
2035  
2036  
2037  
2038  
2039  
2040  
2041  
2042  
2043  
2044  
2045  
2046  
2047  
2048  
2049  
2050  
2051  
2052  
2053  
2054  
2055  
2056  
2057  
2058  
2059  
2060  
2061  
2062  
2063  
2064  
2065  
2066  
2067  
2068  
2069  
2070  
2071  
2072  
2073  
2074  
2075  
2076  
2077  
2078  
2079  
2080  
2081  
2082  
2083  
2084  
2085  
2086  
2087  
2088  
2089  
2090  
2091  
2092  
2093  
2094  
2095  
2096  
2097  
2098  
2099  
2100  
2101  
2102  
2103  
2104  
2105  
2106  
2107  
2108  
2109  
2110  
2111  
2112  
2113  
2114  
2115  
2116  
2117  
2118  
2119  
2120  
2121  
2122  
2123  
2124  
2125  
2126  
2127  
2128  
2129  
2130  
2131  
2132  
2133  
2134  
2135  
2136  
2137  
2138  
2139  
2140  
2141  
2142  
2143  
2144  
2145  
2146  
2147  
2148  
2149  
2150  
2151  
2152  
2153  
2154  
2155  
2156  
2157  
2158  
2159  
2160  
2161  
2162  
2163  
2164  
2165  
2166  
2167  
2168  
2169  
2170  
2171  
2172  
2173  
2174  
2175  
2176  
2177  
2178  
2179  
2180  
2181  
2182  
2183  
2184  
2185  
2186  
2187  
2188  
2189  
2190  
2191  
2192  
2193  
219

PTO/SB/01 (4-95)

Approved for use through 9/30/98 OMB 0651-0032

Type a plus sign (+) inside this box → ☒ Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

# DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION

Declaration OR Declaration  
☒ Submitted with Initial Filing ☐ Submitted after Initial Filing

Attorney Docket No. FMW-RR-PCT-US (I 839)

First Named Inventor EHRFELD, Wolfgang

## COMPLETE IF KNOWN

Application Number

Filing Date

Group Art Unit

Examiner Name

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

## "MICROMIXER"

(Title of the invention)

the specification of which

☐ is attached hereto  
OR

☒ was filed on (MM/DD/YYYY) 06/10/2000 as United States Application Number or PCT International

Application Number PCT/EP00/05366 and was amended on (MM/DD/YYYY) 00/00/0000 (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code § 118 (a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? Yes No
199 27 554.8	DE	06/16/1999		<input type="checkbox"/> <input checked="" type="checkbox"/>
				<input type="checkbox"/> <input type="checkbox"/>
				<input type="checkbox"/> <input type="checkbox"/>
				<input type="checkbox"/> <input type="checkbox"/>
				<input type="checkbox"/> <input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority sheet attached hereto:

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	
		<input type="checkbox"/> Additional provisional application numbers are listed on a supplemental priority sheet attached hereto.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

(July 1998)

Type a plus sign (+) inside this box → ☐

## DECLARATION

Page 2

I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s), or §365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application Number	PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)
	PCT/EP00/05366	06/10/2000	

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority sheet attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Name	Registration Number	Name	Registration Number
HUDAK, Daniel J.	25,879	TYRPAK, Michele M.	47,192
SHUNK, Laura F.	31,423	HUDAK, Daniel J. Jr.	47,669
ROTE, Frank C. Jr.	20,395	FARINE, Cheryl L.	36,796
SHUST, Nestor, W.	23,034		

☐ Additional registered practitioner(s) named on a supplemental sheet attached hereto.

Direct all correspondence to:

Name	HUDAK & SHUNK CO., L.P.A.		
Address	7 West Bowery Street, Suite 808		
Address			
City	Akron	State	Ohio
Country	US	Telephone	330-535-2220
		Fax	330-535-1435
ZIP	44308-1133		

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor:

☐ A petition has been filed for this unsigned inventor

Given Name	Wolfgang	Middle Initial		Family Name	EHRFELD	Suffix e.g. Jr.	
Inventor's Signature	Wolfgang Eurfeld			Date	14.01.02		
Residence: City	Mainz	State		Country	Germany	Citizenship	DE
Post Office Address	Kehlweg 22						
Post Office Address							

City	Mainz	State		ZIP	D-55124	Country	Germany
------	-------	-------	--	-----	---------	---------	---------

☒ Additional inventors are being named on supplemental sheet(s) attached hereto.

Type a plus sign (+) inside this box →

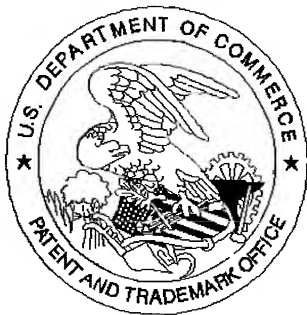
DECLARATION				ADDITIONAL INVENTOR(S) Supplemental Sheet			
Name of Additional Joint Inventor, if any:				<input type="checkbox"/> A petition has been filed for this unsigned inventor			
Given Name	Middle Initial	Family Name	Suffix				
2-00 Frank		MICHEL					
Inventor's Signature			Date				
Frank Michel			11.02.02				
Residence: City	State	Country	Citizenship	DE			
Nieder-Olm		Germany					
Post Office Address							
Eberharder Str. Frank Michel							
Post Office Address							
Austraße 49							
City	State	ZIP	Country				
Nieder-Olm		D-65260	Germany				
Bad Hergentheim							
D-97580							
Name of Additional Joint Inventor, if any:				<input type="checkbox"/> A petition has been filed for this unsigned inventor			
Given Name	Middle Initial	Family Name	Suffix				
2-00 Astrid		LOHF					
Inventor's Signature			Date				
A-LOHF			19.12.01				
Residence: City	State	Country	Citizenship	DE			
Mainz		Germany					
Post Office Address							
Br. Karl Schramm-Str. 7							
Post Office Address							
Lindenplatz 11							
City	State	ZIP	Country				
Mainz		D-55129	Germany				
Karlsruhe							
D-76185							
Name of Additional Joint Inventor, if any:				<input type="checkbox"/> A petition has been filed for this unsigned inventor			
Given Name	Middle Initial	Family Name	Suffix				
2-00 Volker		GRAEFF					
Inventor's Signature			Date				
Volker Graeff			08.02.02				
Residence: City	State	Country	Citizenship	DE			
Mainz		Germany					
Post Office Address							
Oberer Laubenheimer Weg 17							
Post Office Address							
City	State	ZIP	Country				
Mainz		D-55131	Germany				
Name of Additional Joint Inventor, if any:				<input type="checkbox"/> A petition has been filed for this unsigned inventor			
Given Name	Middle Initial	Family Name	Suffix				
Inventor's Signature			Date				
Residence: City	State	Country	Citizenship				
Post Office Address							
Post Office Address							
City	State	ZIP	Country				

☐ Additional inventors are being named on supplemental sheet(s) attached hereto.

(July 1996)



United States Patent & Trademark Office  
Office of Initial Patent Examination -- Scanning Division



Application deficiencies found during scanning:

☒ Page(s) 0 of Drawing were not present  
for scanning. (Document title)

☐ Page(s) \_\_\_\_\_ of \_\_\_\_\_ were not present  
for scanning. (Document title)

☐ *Scanned copy is best available.*